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The effect of intradialytic exercise on biophysiological parameters and quality of life among patients undergoing maintenance hemodialysis in Oman: A comparative observational study

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Abstract

Background: Patients with End-Stage Renal Disease (ESRD) often experience diminished physical function and exercise capacity, which can accelerate disease progression and further compromise their health. Research on the impact of Intradialytic Exercise (IDE) on the quality of life (QOL) for hemodialysis patients in Oman is limited.

Objectives: This study aims to assess the effect of an IDE program on hemodialysis patients in Oman, focusing on both biophysiological parameters and QoL.

Methods: We employed a comparative observational study design involving two groups: one participating in the IDE program and the other serving as a non-participating comparison group from the Al-Seeb dialysis center in Oman. Biophysiological parameters were retrospectively evaluated three months before and after the implementation of IDE. Additionally, mean arterial pressure was measured both prior to the start of the IDE program and again at six months. QOL was assessed post-IDE using the Kidney Disease Quality of Life Short-Form 36 (KDQOL-36) for both groups. Data collection took place from June 2021 to February 2022. We utilized descriptive statistics, independent sample t-test, and chi-square test, analyzing the data with SPSS® software version 23.

Results: The study did not reveal any statistically significant differences in biophysiological parameters between the two groups (p=0.185). However, the exercise group demonstrated significantly higher scores on the physical component summary (M=59.86, SD=23.39) compared to the comparison group (M=44.86, SD=26.33, P=0.001). Although overall QOL scores and subscale scores were higher in the exercise group, these differences did not achieve statistical significance.

Conclusion: This research sheds light on the effects of an IDE program on selected biophysiological parameters and quality of life among hemodialysis patients. While no significant differences were noted in biophysiological measures between the IDE group and the comparison group, improvements in physical health were evident, as indicated by higher KDQOL-36 scores in those participating in the exercise program.

Keywords: Blood pressure, End-Stage Renal Disease, Hemoglobin, Intradialytic exercise, Quality of Life.

Introduction

End-Stage Renal Disease (ESRD) has emerged as a significant public health issue, characterized by the kidneys' inability to function adequately on a daily basis.[1] This condition contributes substantially to the global burden of morbidity and mortality.[2] In the United States, around 786,000 individuals -approximately 2.0 per 1,000 people- are affected by ESRD, with about 71% undergoing dialysis and 29% having received a kidney transplant.[3] According to the US Renal Data System's annual report, several countries in Asia also report high prevalence rates of ESRD, exceeding 300 cases per million population. Notable examples include Thailand (365 pmp), Singapore (347 pmp), South Korea (340 pmp), and Japan (300

pmp).[4]

In Oman, maintenance hemodialysis (MHD) for ESRD patients was first introduced in 1983.[5] The number of patients receiving MHD has seen a significant increase, rising from 1,117 in 2013 to 2,023 by the end of 2018.[5] This growing incidence and prevalence of ESRD have led to an increased demand for renal care and specialized healthcare professionals who require specific training.[6] There is substantial evidence indicating that ESRD is linked to various physical and psychosocial challenges, which can severely impair quality of life.[7-9] Research has consistently shown that physical inactivity among ESRD patients can elevate cardiovascular risks, exacerbate comorbid conditions, diminish quality of life, and increase mortality rates.[10-14]

Promoting higher levels of physical activity among patients undergoing MHD presents a promising strategy to counteract muscle loss and the associated decline in physical function. Evidence suggests that increasing regular exercise participation among ESRD patients by just 10% could potentially reduce mortality rates by 9%.[15,16] This highlights the critical role that exercise plays in enhancing survival outcomes for individuals with ESRD. Additionally, regular physical activity offers both physiological and psychological benefits for these patients.[16,17]

Exercise training can be conducted either outside the dialysis facility or during treatment sessions through intradialytic exercise (IDE). While exercising outside the dialysis center may yield greater improvements in exercise capacity and functional ability, research indicate that adherence to such programs tends to be lower compared to IDE.[18] Common IDE modalities include cycle ergometers, stretch bands, and exercise balls.[19,20] Numerous studies have demonstrated that IDE positively impacts overall health and reduces hospitalization rates among ESRD patients.[21-23] Furthermore, IDE has been shown to help lower blood pressure and improve overall solute removal, particularly phosphorus clearance.[25-28]

Based on the existing literature, there have been a limited number of studies conducted in the region that assess the effectiveness of IDE. For instance, a study in the United Arab Emirates evaluated the impact of IDE on clinical outcomes, behavioral changes, and quality of life (QOL) among patients undergoing MHD. Salhab et al., noted that IDE has yet to be integrated into routine care practices globally. The findings indicated that the IDE program led to a reduction in phosphate levels among patients with hyperphosphatemia, and most participants expressed a positive attitude toward the importance of exercise.[22] Similarly, another study examined the benefits of implementing an IDE program for patients on hemodialysis and peritoneal dialysis in the Kingdom of Saudi Arabia and Egypt. The results demonstrated significant improvements in QOL scores across all domains, as well as enhancements in physical fitness.[28] In Oman, however, IDE has not yet become a standard component of dialysis care. It was only recently, in September 2021, that the Al-Seeb Dialysis Center initiated an IDE program. Unfortunately, this program has not been scientifically evaluated using established research protocols.

Objectives

This study aims to assess the effect of the IDE program on patients with ESRD undergoing MHD in Oman, with a particular focus on biophysiological parameters and quality of life.

Methods

Study design and participants

This study employed an observational comparative design to evaluate the effects of IDE on key biophysiological parameters, including dialysis adequacy, mean arterial blood pressure, and hemoglobin levels among patients with ESRD undergoing MHD in Oman. Participants were assigned to two groups: the exercise group, comprising individuals who participated in the IDE program, and the comparison group, consisting of those who did not [Figure 1].

The study sample was drawn from ESRD patients receiving MHD at the Al-Seeb Dialysis Center in Muscat. This center was selected as the study site because it recently introduced the IDE program, utilizing mini exercise bikes specifically for ESRD patients on MHD. As the only dialysis center in Oman offering this initiative, the Al-Seeb Dialysis Center is one of the largest government facilities providing hemodialysis services in the country. It features five treatment halls -four designated for patients with negative viral statuses and one for those with positive hepatitis C status, along with a separate isolated room for hepatitis B cases. Equipped with 37 dialysis machines, the center can accommodate up to 215 patients across three shifts.

To determine the appropriate sample size, we utilized G*Power 3.0 software[29] to conduct calculations for both paired samples t-tests and independent t-tests. Based on a medium effect size (Cohen's d ranging from 0.50 to 0.80), a statistical power of 0.80, and a two-tailed alpha level of 0.05, we estimated that each group would need 64

participants, resulting in a total sample size of 128 participants. To account for potential missing data, we recruited an additional 25 patients for the comparison group, bringing the total number of participants to 151 (IDE group = 62, Comparison group = 89). We had a drop in the number of participants in each group for various reasons.

The IDE program commenced in September 2021 with the first group consisting of 49 participants. The comparison group included 82 patients recruited through consecutive sampling from the same facility. The study targeted adult Omani patients aged 18 years and older, regardless of gender, who were receiving MHD treatment during a period spanning three months before and three months after the initiation of the IDE program. Exclusion criteria included patients who had been on MHD for three months or less due to the potential for clinical instability and increased risk of adverse medical events such as mortality and hospitalization. Additionally, individuals with severe cognitive impairments or dementia, those with bilateral lower limb amputations, and patients who began MHD after the start of the IDE program were also excluded from participation.

Study instrument

Demographic data has been recorded. To assess QOL, evaluations were conducted for both groups six months after the initiation of the IDE program, utilizing the Arabic version of the 36-item Kidney Disease Quality of Life survey (KDQOL-36).[30] This comprehensive survey is divided into several subscales:

1. General health and functioning (items 1 to 12): This subscale evaluates overall health, limitations in activities, task performance, mood-related factors such as sadness and anxiety, energy levels, and social interactions. The scores from this section contribute to both the Physical Component Summary (PCS) and Mental Component Summary (MCS). Specifically, items 1-5 and 8 have a greater impact on the PCS, while items 6, 7, and 9-12 primarily influence the MCS.

2. Burden of kidney disease (items 13 to 16): This subscale assesses the perceived burden associated with living with kidney disease.

3. Symptoms and problems (items 17 to 28): This section examines various symptoms and issues experienced by patients, including chest pain, cramps, itching, breathlessness, poor appetite, and complications related to vascular access.

4. Impact of kidney disease (items 29 to 36): The final subscale focuses on the broader impacts of kidney disease on daily life.

Each subscale score ranges from 0 to 100, with higher scores indicating better health outcomes. In this study, the KDQOL-36 exhibited strong reliability, achieving a Cronbach's alpha of 0.93. The reliability coefficients for the individual subscales were as follows: physical functioning subscale (PCS) = 0.757, mental health subscale (MCS) = 0.675, burden of kidney disease = 0.705, symptoms and problems = 0.874, and effects of kidney disease = 0.854.

Data collection procedure

Data collection commenced on June 1, 2021, and concluded on February 28, 2022. Each participant was assigned a unique identifier: those involved in the IDE program were designated with an "E," while non-exercising participants received an "N." Researchers conducted interviews with participants after the start of their hemodialysis sessions. Following the acquisition of informed consent, medical records were reviewed, and data collection sheets were completed.

Pre- and post-dialysis blood pressure readings were recorded for the last three dialysis sessions, allowing for the calculation of Mean Arterial Pressure (MAP) during data analysis. Additional biophysiological parameters were gathered over the three months leading up to the IDE program's initiation. Pre-dialysis readings were collected between June 1 and August 30, 2021, prior to the IDE program's start in September 2021. Post-IDE readings were collected three months after the program began, from December 1, 2021, to February 28, 2022.

Regarding QOL assessments, KDQOL-36 surveys were administered to participants six months after they began participating in the IDE program (post-IDE phase only). To ensure consistency between the QOL data and other collected information, the same unique identifier was used for both the QOL survey and socio-demographic sheets.

IDE program

The IDE program currently operates at the Al-Seeb Dialysis Center, where participants engage in cycling on mini exercise bikes during their dialysis sessions. These portable bikes are securely fastened to the floor or beds, minimizing the risk of injury from improper use or equipment malfunctions, thereby prioritizing participant safety. The IDE protocol begins one hour into the hemodialysis session with a five-minute warm-up to prepare the body for exercise. This is followed by 30 minutes of cycling, gradually increasing in intensity, and concluding with a five-minute cool-down period. Throughout each session, participants are closely monitored using an exercise cart that emphasizes safety measures before, during, and after exercise.

An assigned nurse plays a crucial role in overseeing the

participants' well-being. Before exercise begins, the nurse checks vital signs -such as blood pressure, heart rate, and random blood sugar levels for diabetic patients- to ensure readiness. During the cycling activity, the nurse remains vigilant for any warning signs that may require stopping the exercise, including shortness of breath, nausea, vomiting, cyanosis, changes in communication, joint pain, chest discomfort, and fatigue. After the exercise session, the nurse reassesses vital signs and overall health to ensure participants are stable.

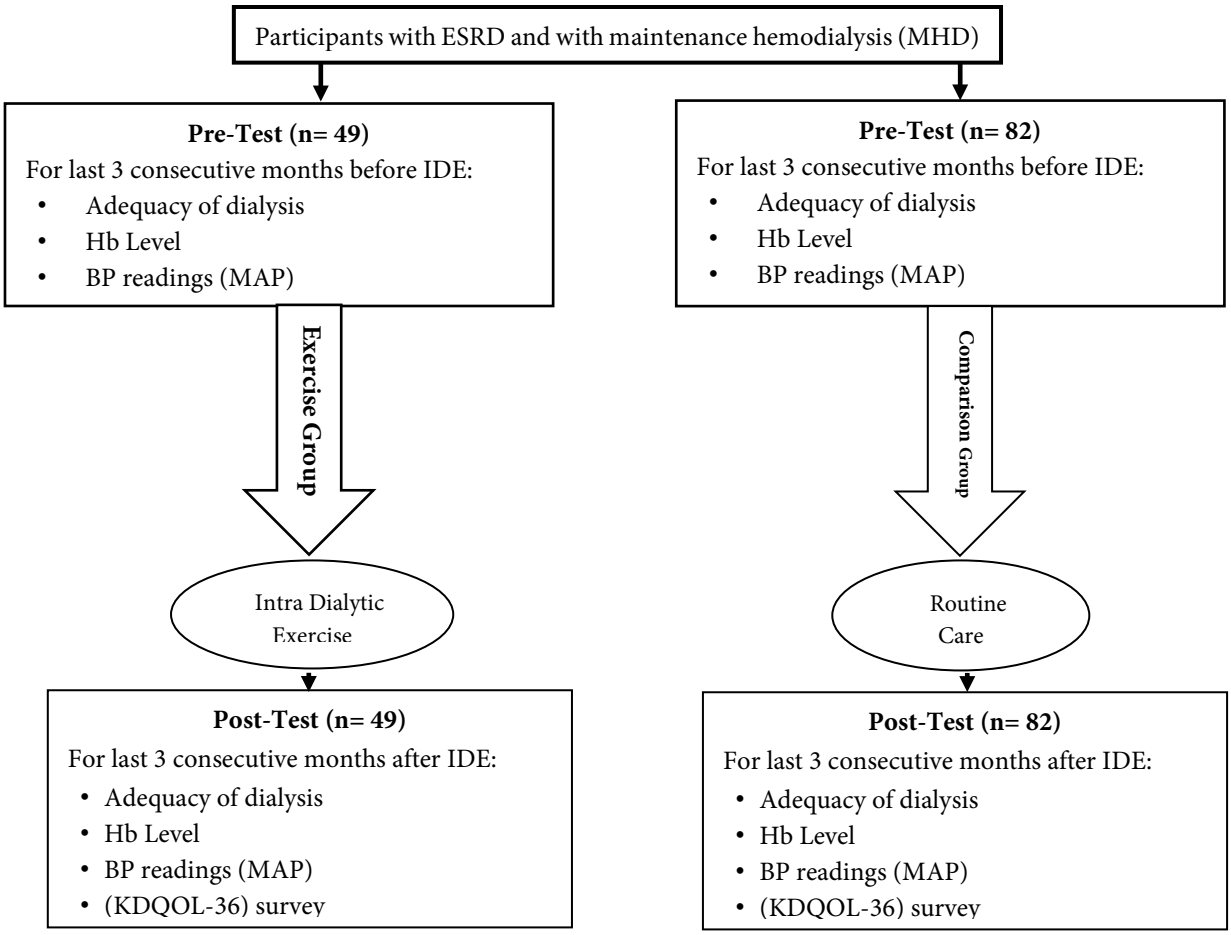

Figure 1. Diagrammatic representation of the study design

Data analysis

To evaluate the effect of the IDE program on dialysis adequacy, MAP, hemoglobin (Hb) levels, and QOL among patients with ESRD at the Al-Seeb Dialysis Center, we utilized descriptive statistics such as percentages, means, and standard deviations with SPSS® version 23. An independent samples t-test was employed to compare quantitative variables between groups, while the chi-square test was used to compare categorized variables between two groups. A significance level of less than 0.05 was considered in all statistical analyses. Frequency tables and descriptive statistics were generated to explore the data comprehensively. We assessed distribution normality by examining histograms along with skewness, kurtosis, median, mean, and mode values.

Ethical considerations

Before launching the study, we obtained approval from the Research and Ethics Committee at the College of Nursing, Sultan Qaboos University, as well as from the Directorate of Research and Studies at the Ministry of Health (MoH/CSR/21/25357). Additionally, we secured an administrative approval letter from the Directorate General of Health Services in Muscat to access the Al-Seeb Dialysis Center.

Eligible participants were provided with an informed consent form detailing the study's aims, objectives, and potential benefits. We ensured that participants understood their rights regarding confidentiality, voluntary participation, and the ability to withdraw at any time without affecting their treatment. They were also informed that their participation would not influence their medical care. All medical information collected was strictly for research purposes and maintained in a secure location. Data from participants were handled solely by the investigator and stored in a locked file cabinet.

Table 1. Comparison of demographic variables among study groups (N=131)

Variable		Exercise (n = 49) (%)	Comparison (n = 82) (%)	Chi square test	P value
Mean Age (SD)		45.7 (14.2)	55.3 (14.6)	t = 3.6	< 0.001
Age Groups, years	20–39	17 (34.7)	16 (19.5)	10.73	0.005
	40–59	22 (44.9)	26 (31.7)		
	≥ 60	10 (20.4)	40 (48.8)		
Sex	Male	36 (73.5)	38 (46.3)	9.18	0.003
	Female	13 (26.5)	44 (53.7)		
Smoking	Yes	3 (6.1)	6 (7.3)	0.068	0.794
	No	46 (93.9)	76 (92.7)		
Diabetes Mellitus	Yes	19 (38.8)	36 (43.9)	0.331	0.588
	No	30 (61.2)	46 (56.1)		
Hypertension	Yes	32 (65.3)	61 (74.4)	1.229	0.321
	No	17 (34.7)	21 (25.6)		
Bone disease	Yes	2 (4.1)	8 (9.8)	1.4	0.320
	No	47 (95.9)	74 (90.2)		
Cardiac disease	Yes	3 (6.1)	21 (25.6)	7.784	0.005
	No	46 (93.9)	61 (74.4)		
Vascular access type	AVF	43 (87.7)	65 (79.3)	1.55	0.246
	AVG	2 (4.1)	5 (6.1)		
	CVC	4 (8.2)	12 (14.6)		
Dialyzer size, m^2	15	5 (10.2)	23 (28)	6.14	0.046
	18	33 (67.3)	47 (57.4)		
	20	11 (22.5)	12 (14.6)		
Duration of receiving current renal treatment	(1- 5 years)	23 (47)	40 (48.8)	0.210	0.900
	(6-10 years)	18 (36.7)	31(37.8)		
	> 11 years	8 (16.3)	11 (13.4)		
Frequency of dialysis per week	Twice	1(2)	2 (2.4)	0.627	0.731
	Thrice	48 (98)	80 (97.6)		
Dialysis hours per session	3:30 hrs	5 (10.2)	15 (18.3)	0.627	0.731
	4 hrs	44 (89.8)	67 (81.7)		
What is your usual intradialytic weight gain?	1 kg to 2kg	3 (6.1)	5 (6.1)	0.006	0.997
	2.1 kg to 3 kg	17 (34.7)	29 (35.4)		
	Above 3.1 kg	29 (59.2)	48 (58.5)		
Have you shortened HD time?	Yes	28 (57.1)	63 (76.8)	5.6	0.030
	No	21 (42.9)	19 (23.2)		
Missing HD sessions last three months	Missed > 3 sessions	2 (4.1)	5 (6.1)	2.474	0.290
	Missed (1-3) sessions	4 (8.2)	2 (2.4)		
	None	43 (87.7)	75 (91.5)		
		Mean (SD)	**Mean (SD)**	***t* (*df*)**	**P value**
Mean blood flow rate, mL/min		289.0 (20.7)	275.5 (30.0)	2.80 (129)	0.006
Mean Dialysate flow rate, mL/min		614.3 (54)	603.7 (48.3)	1.20(129)	0.25

AVF: Arteriovenous fistula, AVG: Arteriovenous Graft, CVC: Central Venous Catheter

Results

The exercise group was significantly younger than the comparison group, with mean ages of 45.7 and 55.3 years, respectively (P<0.001). Additionally, significant differences were observed across various age categories (P=0.005). A greater proportion of males participated in the exercise group compared to the comparison group (73.5% vs. 46.3%, P=0.003). Furthermore, the exercise group had a lower incidence of cardiac disease, with only 6.1% of participants affected compared to 25.6% in the comparison group (P=0.005). The size of the dialyzer also differed significantly between the groups (P=0.046). The comparison group reported a higher percentage of patients who shortened their hemodialysis sessions (76.8% vs. 57.1%, P=0.030). Lastly, the exercise group exhibited a higher mean blood flow rate during dialysis (289.0 vs. 275.5 mL/min, P=0.006) [Table 1].

We also analyzed the impact of IDE on various biophysiological parameters. The findings revealed a statistically significant difference in post-IDE MAP after hemodialysis sessions, with the exercise group demonstrating a higher MAP (111.69 vs. 106.58 mmHg, P=0.031). However, no significant differences were noted in the urea reduction ratio (URR), MAP before HD sessions, or Hb levels between the two groups, both before and after IDE [Table 2].

Effects of IDE on quality of life

The study indicated that the PCS score was significantly higher in the exercise group compared to the comparison group (59.86 vs. 44.86, P=0.001). However, no significant differences were found in the overall QOL score (65.46 vs. 61.01, P=0.185), MCS score (59.89 vs. 55.04, P=0.242), burden of kidney disease score (58.29 vs. 54.34, P=0.371), symptoms/problems related to kidney disease score (70.23 vs. 69.11, P=0.766), or effects of kidney disease score (69.80 vs. 69.10, P=0.863) [Table 3].

Table 2. Effects of IDE on mean levels of biophysiological parameters

	Score	Group	M± SD	*t (df)*	P value
Urea reduction ration (URR), %	Pre IDE	Exercise	68.96±7.66	- 0.817 (129)	0.415
		Comparison	70.17±8.49		
	Post IDE	Exercise	69.06±8.65	-1.172 (129)	0.243
		Comparison	70.80±8.18		
Mean Arterial Pressure (MAP), mmHg	Pre-IDE (Pre HD session)	Exercise	111.22±13.75	1.51 (129)	0.13
		Comparison	106.67±18.26		
	Pre-IDE (Post HD session)	Exercise	108.28±15.06	1.22 (129)	0.22
		Comparison	104.88±15.49		
	Post-IDE (Pre HD session)	Exercise	110.89±14.21	0.35 (129)	0.74
		Comparison	109.89±17.97		
	Post-IDE (Post HD session)	Exercise	111.69±11.04	2.01 (129)	0.031
		Comparison	106.58±15.58		
Hb Level, g/dL	Pre IDE	Exercise	12.461±4.21	0.913 (128)	0.826
		Comparison	11.71±4.66		
	Post IDE	Exercise	12.44±4.11	1.961 (129)	0.140
		Comparison	11.25±1.35		

Table 3. Effects of IDE on mean quality of life scores

Characteristics	Exercise (n=49) Mean±SD	Comparison (n=82) Mean±SD	*t (df)*[*]	P value
QOL – Total score	65.46±18.74	61.01±18.35	1.331	0.185
Physical component summary (PCS)	59.86±23.39	44.86±26.33	3.285	0.001
Mental component summary (MCS)	59.89±21.87	55.04±23.43	1.176	0.242
Burden of Kidney Disease	58.29±23.84	54.34±24.66	0.897	0.371
Symptoms/problems of Kidney Disease	70.23±21.70	69.11±20.28	0.299	0.766
Effects of Kidney Disease	69.80±23.32	69.10±21.81	0.173	0.863

[*]df = 129 for all comparisons, QOL: Quality of life

Discussion

The results of this study indicate that a significant majority of the hemodialysis patients involved were male, with a mean age of 51.8 years. This aligns with findings from previous research conducted in Oman. For instance, Al-Za'abi et al., reported that 56% of patients diagnosed with ESRD requiring renal replacement therapy (RRT) were male.[5] Similarly, Al Salmi et al., found that men constituted 54% of the patients undergoing dialysis at the Bowsher Dialysis Unit in Muscat, Oman.[7]

In our study, hypertension and diabetes emerged as the most prevalent comorbidities among participants, affecting 71% and 42%, respectively. These results are consistent with findings from another Omani study, where Al Salmi et al., noted that 44.9% of HD patients had diabetes mellitus.[7]

Interestingly, our research revealed no significant difference in dialysis adequacy, as measured by the Urea Reduction Ratio (URR), between the IDE group and the comparison group. This finding aligns with the results of previous studies;[31,32] however, explanations for the lack of significant differences varied. For example, Stuart et al., suggested that participants may not have been able to achieve a sufficient increase in exercise intensity to enhance dialysis adequacy due to advanced age (over 66 years), multiple comorbidities (more than two), and a prolonged disease burden (over five years on dialysis).[31] While our study did not specifically control for exercise intensity, this rationale remains applicable. Notably, in our exercise group, hypertension and diabetes were prevalent, affecting 65.3% and 38.8% of participants, respectively. Additionally, the mean duration of HD treatment among participants was 6.4 years, which may have hindered their ability to reach the exercise intensity necessary for improving dialysis adequacy.

Similar to our findings, De Vos et al., reported no significant difference in dialysis adequacy after three weeks of IDE, even when cycling was included. They proposed that any improvements in dialysis adequacy resulting from IDE are more likely to manifest over the long term rather than immediately.[32] Although our study assessed the effect of IDE on dialysis adequacy after three months, it is possible that a longer duration may be required for any positive effects to become clinically evident.[32]

Contrasting with our results, several studies have documented beneficial effects of IDE on dialysis adequacy.[33-35] These discrepancies could be attributed to various factors such as participants' comorbidities, overall disease burden, duration of IDE, lack of synergistic components (like functional training or exercise counseling), absence of blood flow restriction (BFR), reliance solely on aerobic IDE without incorporating resistance exercises, non-compliance with IDE protocols, excessive intradialytic weight gains, reduced prescribed dialysis time, and missed dialysis sessions. Due to the observational nature of our study, we were unable to control for these variables. However, the program is already established and managed by the healthcare team at the center. Future prospective studies, such as randomized clinical trials, should consider controlling for these factors to draw more definitive conclusions regarding the effectiveness of IDE on dialysis adequacy among HD patients in Oman.

The current study found no statistically significant difference in MAP before hemodialysis sessions between the two groups after implementing the IDE program. This aligns with findings from Huang et al., who also reported no significant differences in pre-dialysis and post-dialysis blood pressure between the exercise and control groups after six months of IDE. Huang et al. attributed this outcome to factors such as intradialytic weight gain (averaging 2.8 kg in the exercise group) and low adherence rates, with only 60% of participants consistently following the IDE program, both of which have been linked to elevated blood pressure.[36] Similarly, in our study, intradialytic weight gains and noncompliance may have contributed to the limited impact of the IDE program on mean MAP.

Additionally, we observed no changes in Hb levels between the study groups, a finding that is consistent with previous research.[13,35] For instance, Lin et al., reported that the mean Hb level in the exercise group decreased from 10.1 g/dL to 9.9 g/dL by the end of their trial. They suggested that factors such as a patient's nutritional status and dietary habits could significantly affect dialysis parameters like Hb levels and electrolytes.[37] Unfortunately, our study did not assess nutritional status or eating habits, which may explain the limited clinical impact of the IDE program on Hb levels. Furthermore, approximately 91.6% of patients in our study were receiving erythropoietin injections, which could have masked any potential effects of the IDE program on Hb levels.

Regarding QOL, we found no statistically significant differences between the exercise and comparison groups in mean total QOL scores or any of the subscales, except for PCS, where the exercise group scored significantly higher (59.86 versus 44.86). Although the mean total QOL scores and subscale scores for the exercise group were higher than those of the comparison group, they did not reach

statistical significance. This finding is in line with Greenwood et al., who noted slight increases in total QOL scores and subscales at the end of their study compared to baseline, though these improvements were not statistically significant either. Greenwood et al. attributed these results to poor compliance, with only 18% of participants adhering to the planned IDE program regarding duration and intensity.[38]

In our study, we did not regularly or accurately assess compliance with the IDE protocol, which may have limited our understanding of its effects on patients' QOL. Future prospective studies should prioritize regular assessments of compliance with the IDE protocol to gain deeper insights into its impact on patients' quality of life.

It is essential to recognize that the varying abilities of patients to engage in intradialytic exercise may have influenced the study's outcomes. Factors such as individual fitness levels, comorbidities, and personal preferences likely affected participation rates. Patients with higher fitness levels or fewer health issues might have been more motivated to participate in the exercise program, which could, in turn, impact key outcomes like dialysis adequacy and quality of life. Therefore, it is crucial to consider these differences in participation when interpreting the findings. In contrast to our study, other research has shown that IDE can lead to improvements in QOL.[13,23,36,38,39] These discrepancies may stem from various factors, including non-compliance with the IDE program, shorter durations of exercise, reliance on aerobic activity alone, patient age, education level, frequency and duration of dialysis sessions, income levels, lifestyle changes due to hemodialysis treatment, and the presence of diabetes and other comorbidities—all of which can significantly affect QOL.

This study has several notable strengths. First and foremost, it is the first investigation conducted in Oman to assess the effectiveness of an IDE program. The results can serve as a foundation for future research and contribute to the refinement and sustainability of the program. Additionally, the study highlights factors that could influence the program's effectiveness, providing valuable insights for healthcare teams at the Al-Seeb dialysis center on how to enhance program quality. Finally, this research may serve as a reference point for national initiatives aimed at improving IDE programs.

However, there are limitations to consider. The study was conducted in a single setting, which may limit the generalizability of the findings. Additionally, as an observational study, it lacked researcher control over the program's implementation. The retrospective nature of data collection restricted our ability to manage variables that could affect program effectiveness. Future research should consider designing a prospective randomized clinical trial to allow for better control over these variables and data collection methods. Furthermore, this study assessed QOL only after the IDE phase without baseline data for a more accurate evaluation of improvement. The typical pre-IDE data for other variables may have also contributed to the lack of statistical significance in the results. Most importantly, we did not account for potential differences in baseline characteristics between the intervention and comparison groups; such differences could confound our findings and should be addressed in future studies to ensure more reliable conclusions.

Conclusions

ESRD is characterized by a significant loss of kidney function and poses a serious public health challenge globally. Patients with ESRD often experience reduced capacity for physical activity, making it vital to implement strategies aimed at enhancing their physical health and overall quality of life. Our study demonstrated that IDE contributed positively to the physical health of participants in the exercise group. While the overall QOL scores and subscale scores for this group were higher than those of the comparison group, these differences did not achieve statistical significance. Additionally, no statistically significant differences were observed between the groups regarding other biophysiological parameters such as dialysis adequacy, hemoglobin levels, and MAP. These outcomes may be attributed to various factors, including non-adherence to the IDE program, duration of exercise sessions, sample size, type of exercise performed, blood flow during hemodialysis sessions, dialysis regimens, dietary habits, intradialytic weight gains, comorbidities, and overall disease burden.

Acknowledgment

We extend our heartfelt gratitude to all patients who participated in this study.

Competing interests

The authors declare that they have no competing interests.

Abbreviations

Blood Flow Restriction: BFR; Blood Pressure: BP; End-Stage Renal Disease: ESRD; Intradialytic Exercise: IDE; Kidney Disease Quality of Life Short-Form 36: KDQOL-36; Mean Arterial Pressure: MAP; Mental Component Summary: MCS; Maintenance Hemodialysis: MHD; Physical Component

Summary: PCS; Quality of Life: QOL; Renal Replacement Therapy: RRT; Urea Reduction Ratio: URR.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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None.

Role of the funding source

None.

Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. Before launching the study, we obtained approval from the Research and Ethics Committee at the College of Nursing, Sultan Qaboos University, as well as from the Directorate of Research and Studies at the Ministry of Health (MoH/CSR/21/25357). Additionally, we secured an administrative approval letter from the Directorate General of Health Services in Muscat to access the Al-Seeb Dialysis Center.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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